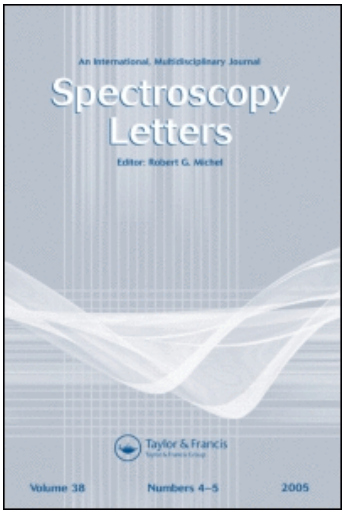

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SPEED OF GAMMA RAYS EMITTED BY HIGH SPEED PARTICLES

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Abstract: Experiments alleged to confirm the absolute speed of light by Sadeh, Fillipas and Fox, and those done at CERN on the emission of gamma rays by high speed particles are shown to be inconclusive. These experiments have been interpreted quantitatively on the basis of an "extinction" hypothesis formulated by J. G. Fox for which there is no experimental confirmation or denial. Rather than confirming the absolute speed of light, these null result experiments can also be regarded as merely showing the obliteration of the relative speed of light as it propagates through various media.

SADEH EXPERIMENT

Sadeh[1] presented the results of his experiment in 1963 on the time of flight of gamma rays emitted as a result of the in-flight annihilation of positrons. Sadeh considered that in the collision of a free positron "the center-of-mass system of the positron and electron moves with a velocity close to $\frac{1}{2}c$." The product of annihilation constitutes two gamma rays emitted in opposite directions along the same straight line (in the c.m. system) each with speed c. The c.m. system was considered to act as a moving source of gamma rays relative to the laboratory with respect to which the negatrons in a plastic target (on which the positrons were incident) were essentially at rest. The essentials of Sadeh's arrangement is shown in Figure 1 in which S is the positron source, T is the

plastic target in which the in-flight annihilation products, the gamma photons, are generated that are detected by the sodium iodide scintillation crystals C_1 and C_2.

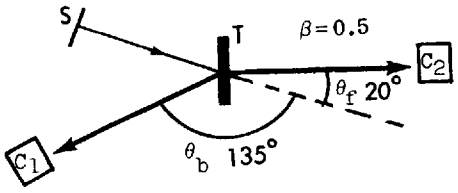

FIG. 1. Sadeh Experiment

Sadeh thought that a transit time difference (∿1.5n sec) of the gamma rays in the forward and backward directions could be observed if the speed of light (c±v) depended on the motion of its source. He sought to measure the transit time difference, if any, by coincidence counting techniques. He detected no time difference and concluded that his observations provided experimental corroboration of the second Einstein postulate that the speed of light is independent of the motion of its source, which is to say that the speed of light is absolute.

Relative to the c.m. the two electrons approach the c.m. each with speed u equal to 0.5c and the total energy before annihilation is $2m_oc^2/\sqrt{(1-\beta^2)} = 1.180$ Mev; $\beta = u/c$. After annihilation two gamma rays are emitted in exactly opposite directions each with energy hν equal to 0.590 Mev, or half the total energy before annihilation.

Relative to the laboratory, the negatron is at rest, the c.m. moves with speed u equal to 0.5c, and the positron moves (according to the Einstein "addition" theorem) with speed v equal to $2u/(1 + u^2/c^2)$ or 0.8c. The laboratory frequencies of the forward and backward emitted gamma rays, coming from the

annihilation complex (the c.m.) that moves relative to the laboratory with speed βc equal to 0.5c, are given according to the Einstein-Doppler formula as

$$\nu_f = \nu\sqrt{(1-\beta^2)}/(1-\beta\cos\theta_f) \quad \text{and} \quad \nu_b = \nu\sqrt{(1-\beta^2)}/(1-\beta\cos\theta_b).$$

The numerical results in terms of energy are

$$h\nu_f = 1.63h\nu = 0.96\text{Mev} \quad \text{and} \quad h\nu_b = 0.68h\nu = 0.40 \text{ Mev}.$$

In Sadeh's arrangement "the only gamma rays gating the multichannel analyzer were those between 0.511Mev and 0.65Mev (the energy range of the annihilation-in-flight gamma rays from our source)." Sadeh mistakenly blinded his apparatus to the in-flight annihilation product gamma rays whose Doppler shifted energies were above and below the incorrectly calculated response range in his apparatus.

Sadeh's claimed 'coincidence' observations were spurious and accidental. Something like ninety-five percent of the incident positrons from the source are first stopped in the target and then annihilated. The at-rest annihilation product gamma rays go off, relative to the laboratory, with speed c in opposite directions along the same straight line in accord with the conservation of momentum. Sadeh's non-colinear detectors were therefore unable to yield true coincidence counts for the oppositely directed colinear at rest annihilation gamma rays to which his blinded detectors were alone able to respond in true coincidence. His coincidence counts were therefore purely spurious and quite accidental. Even with correctly responding detectors Sadeh's counts would still have been accidental since the angle between the detectors was incorrect.

Sadeh's efforts have been criticized as inconclusive by Filippas and Fox (1964)[2] on the grounds that the relative speed ($c \pm v$) of the gamma rays generated within the plastic target may have been "extinguished" or depreciated to c on propagating out of the target material. The same argument was also brought against a related effort by Alvager, Nilsson, and Kjellman (1963)[3,4] for gamma rays (from recoiling nuclei generated in a carbon target) that also passed through a vacuum chamber window. The Filippas-Fox experiment was intended to measure the relative speed of gamma rays from the decay in flight (at 0.2c) of neutral pions in liquid hydrogen. In the Filippas-Fox arrangement the gamma rays passed through stainless steel (0.25mm thick), aluminum (2mm thick) and copper (1.6mm thick) in addition to about 10 cm of liquid hydrogen. On the basis of long chains of supposition and interference the experimental results were claimed to be in "complete disagreement" with the relative speed of light. It was noted of the data that "Chi square tests yield the following limits on the value of k in the expression $c \pm kv$ for the γ-ray speed: $k \leq 0.5$ with a confidence level of 99.9%, $k \leq 0.4$ with a confidence level of 90%." Thus k was not limited to just the value of zero. It would seem possible to interpret such a situation as indicative of a contradiction of the absolute speed of light; i.e., $k \neq 0$.

"EXTINCTION"

Fox's quantitative estimate of the extinction distance as $\lambda/2\pi(n-1)$ is based on an extension from normal dispersion in the visible optical spectrum that excludes anomalous dispersion regions where n can be less than unity. The index of refraction

(normal dispersion) of aluminum is known from measurement to be slightly less than unity in the x-ray region while the index of refraction of liquid sodium at its own D line is 0.0045.[5] The Fox extinction length formulation, in addition to its limitation,to normal dispersion, becomes meaningless for n less than unity.

Fox (1965)[6] presented some very challengeable arguments on the 'extinction' effect as a quantitative basis from which he freely criticized many other experiments as inconclusive. These experiments could have been evaluated on much more practical considerations, as he did in showing that the Rotz (1963)[7] experiment was inconclusive. The 'extinction' effect is predicated on the assumption that a light wave incident on matter is annihilated during which process a 'new' light wave is generated that propagates through the matter. It is one of a number of hypotheses that could be put forth to describe the propagation of light in matter. There is no experimental evidence whereby the mechanism of this 'extinction' effect can be reasonably directly inferred. It is not known how to distinguish the incident wave from its alleged offspring in the matter, if indeed the incident wave is 'extinguished' rather than altered by interaction with the matter. Fox observed in a footnote (p. 15)[6] that in the absence of experimental data on extinction "Uncertainty about how to estimate [not measure] the effect for γ rays delayed publication of the [Filippas-Fox[2]] experiment for many months." On the very next page Fox[6] declares that "Finally we have fairly good direct experimental verification of the extinction length for x rays[12]." The

superscript 12 refers back to Fox's own work with Filippas[2] which was delayed in publication by uncertain estimates of the 60m of air. On the basis of experimentally unsupported extinction length computations it was asserted that the modification of the possible relative speed of the gamma rays was negligible, and that the inferred gamma ray speed from the moving pion source was absolute. In the absence of any experimental evidence at all on the extinction hypothesis the counter assertion that the speed of the gamma ray was attenuated from c+kv to c has qualitative significance that renders the experimental results ambiguous and inconclusive. The substitution of one hypothesis (extinction) to establish another (absolutivity) is not conducive to productive results.

CONCLUSIONS

There is an inherent interpretive asymmetry in these supposedly quantitative experiments on the speed of light from moving sources. There are two nagging problems of fact to start with. Firstly, the speed of the source (a specific decaying particle) within the target material, at the instant of emission of a photon, is ambiguous to the extent that it has not been directly measured. Secondly, the variation of the relative speed of a photon within any given medium (the target material or the air) is completely unknown because there is no direct experimental evidence. Prescinding from the first difficulty a negative experimental result can, in the absence of direct quantitative experimental data on extinction, be qualitatively and circumstantially interpreted as showing either that the added source motion was obliterated by

propagation of light through a medium or that it was not so obliterated and that the speed of light is absolute. A positive experimental result on the other hand is free of the inconclusive dilemma of a dual interpretation. The positive result, if it is not spurious, leaves no other interpretation save that the speed of light from a moving source is not absolute but relative. If the result is indeed not a spurious one, it becomes possible to regard the experiment as also yielding evidence on the effect of a medium on the propagation of light from a moving source.

What, in effect, has been done in these gamma ray experiments is to cause attention to be shifted to an essentially renewed hypothesis; namely, an alleged extinction effect for which there is no clear experimental evidence at all. This unsubstantiated "effect" is actually nothing but a theoretical calculation based on an assumed valid extrapolation from the visible spectrum in which region there is not one shred of experimental evidence to begin with. The logical circumlocutions and calculations are then asserted as if they were hard experimental fact rather than the suppositions they really are. It is by means of this unrecognized verbal slight of hand that the validity of the second Einstein postulate is asserted by recourse to the magical "experiment" of an hypothesis of extinction. The emperor's invisible gold clothing is now imagined to represent valid experiment.

The interpretation of these gamma ray experiments is neither simple nor direct. They are predicated on a long chain of (at times dubious) experimental inference and theoretical

assumptions. Some of them are so elliptically reported that a careful and impartial evaluation is impossible. It is all too easy to be misled by the sheer number of such seemingly corroborative experiments, taken at face value, into a false sense of valid confirmation of the postulate of the absolute speed of light. Particularly is this true if there is, as there seems to be, a widespread disposition to find a priori what is regarded as theoretically unavoidable. With what caution should a critique of the consensus be unfolded?

There is considerable merit in some of Fox's (1965)[6] closing remarks which seem so relevant: "One might wish there were a broader experimental base for deciding a question as fundamental to practically all of physics as this. One might also hope that we will someday have results free of the slight [!] ambiguities which still remain in the interpretation of some of these experiments." Later Fox (1967)[10] concluded, "The whole history of this matter of proving [rather than examining] the constancy of c has involved an unusually large number of errors. There may be more but it seems that at least we now understand the role of extinction." Hardly!

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